Improved image quality with elliptical orbits and distance-weighted backprojection SPECT reconstruction

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The image quality of SPECT bone scans is enhanced through the use of distance-weighted filtered backprojection in association with elliptical orbit acquisition.

Key words: Radionuclide studies, Single photon emission computed tomography, Reconstruction techniques

INTRODUCTION

Phantom studies[1] in SPECT imaging have shown improved contrast and spatial resolution when the data is acquired with the camera rotating in an elliptical (or body) contour orbit versus the conventional circular orbit. Tomograms with improved contrast and spatial resolution have been obtained[2,3] from circular orbit acquisition data when reconstructed with the distance-weighted filtered backprojection (DWT) algorithm instead of conventional (CONV) 360 degree reconstruction techniques. The purpose of this study is to compare the image quality of elliptically and circularly acquired tomograms and to evaluate them in combination with DWT in SPECT bone imaging.

MATERIALS AND METHODS

SPECT acquisitions of the pelvis were performed on five patients referred for bone imaging. Scans were acquired 2–4 hours after the injection of 25 mCi (925 MBq) of Tc-99m methylene diphosphonate. Imaging was first performed using an elliptical orbit, followed immediately thereafter by the circular orbit acquisition. A 500 mm field-of-view gamma camera was equipped with a low-energy general purpose

collimator. View data were acquired with 1.2 magnification into a 128×128 digital matrix with each pixel in the array having a linear dimension of approximately three millimeters. For each 360 degree rotation, the camera stopped and acquired data for 10 seconds in each of 128 frames.

Using a commercially available system, elliptical orbit acquisitions were obtained through synchronizing the movement of the patient table and the circularly rotating camera system.* The parameters required for the system to describe an elliptical path were set before the actual acquisition. This was accomplished by moving the table in each of the anterior, left lateral, right lateral, and posterior views until the patient almost touched the camera in that view. The position of the table in these views was stored in the computer, which subsequently controlled the table-camera movement during the data acquisition. Circular orbit acquisitions were performed on the same system with the parameters set such that the radius of rotation was as small as possible.

CONV reconstructions were performed with a standard 360 degree backprojection algorithm that gave equal weighting to data from all acquired views. The DWT algorithm applied a variable weighting to the data such that a given pixel in a reconstructed transaxial slice received a greater contribution from the closest views.[2] The joint movement of the camera and table was implemented on the elliptical acquisition system such that the center of rota-

tion was identical to that of the circular scanning system. Thus, the same backprojection algorithm (CONV or DWT) was applied to both the circular and elliptical acquisitions. No pre- or post-processing filtering was performed.

Two observers (WAF and RIP) visually assessed matched sets of transaxial images. In order to compare quantitatively the acquisition and reconstruction combinations, a transaxial slice at the level of the body of the sacrum was reconstructed, and profile curves were obtained from a 14-pixel-thick band across the transaxial images encompassing the body of the sacrum and the sacroiliac joint regions. Sub-

sequently, the 128×128 planar views were minified into a 64×64 matrix and a corresponding transaxial slice similarly processed. The ratio of the maximum count in the region of the body of the sacrum to the average of the two minimum count values in the two regions between it and the sacroiliac joint regions was obtained as a measure of contrast (Table 1).

RESULTS

In the blinded comparison, the tomograms reconstructed from the elliptical acquisitions were identified by both observers as having the superior spatial resolution and contrast in all five cases.

Figure 1 shows tomograms corresponding to the different acquisition and reconstruction techniques for a 128×128 acquisition matrix size. The corresponding images for a 64×64 acquisition matrix are shown in Fig. 2.

The elliptically acquired and DWT reconstructed images (Figs. 1A and 2A) and the elliptically acquired CONV-reconstructed images (Figs. 1B and 2B) show better delineation of the sacroiliac joints and the body of the sacrum than do the images obtained with circular acquisitions. The profile curves are displayed in Figs. 3 and 4, and Table 1

Table 1 Contrast in the region of the sacrum

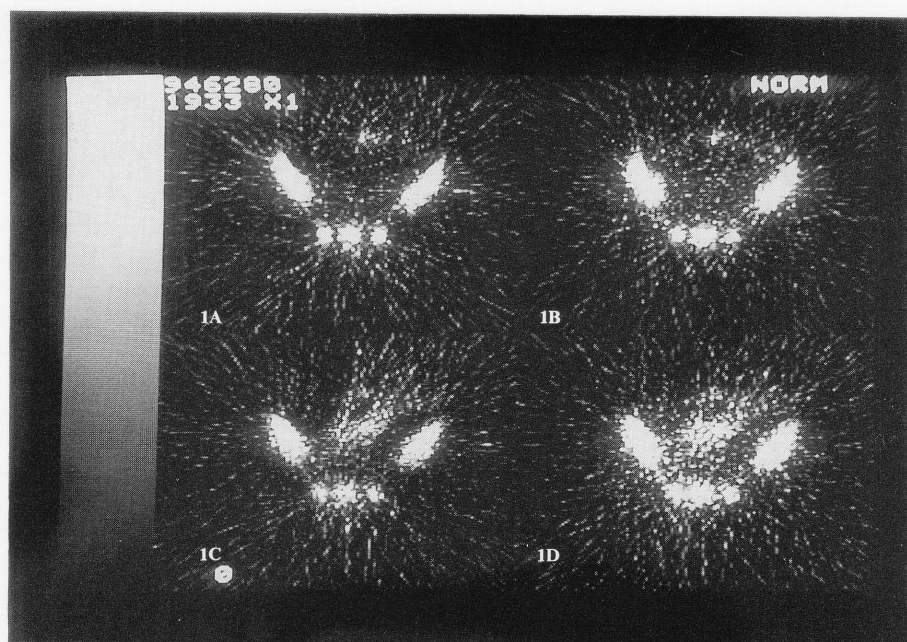| Acquisition matrix	Acquisition	Reconstruction	Contrast
128×128	Elliptical	Distance-weighted	4.2
	Elliptical	Conventional	3.2
	Circular	Distance-weighted	2.4
	Circular	Conventional	2.0
64×64	Elliptical	Distance-weighted	3.0
	Elliptical	Conventional	2.3
	Circular	Distance-weighted	2.0
	Circular	Conventional	1.7

Fig. 1 For data acquired with a 128×128 matrix, a transaxial slice through the sacrum is shown.

1A: (UPPER LEFT) Elliptical acquisition: Distance-weighted reconstruction.
1B: (UPPER RIGHT) Elliptical acquisition: Conventional reconstruction.
1C: (LOWER LEFT) Circular acquisition: Distance-weighted reconstruction.
1D: (LOWER RIGHT) Circular acquisition: Conventional reconstruction.

The circular acquisition was obtained after the elliptical acquisition. The filling bladder during the second scan produced the additional radioactivity in the central region of the SPECT images.
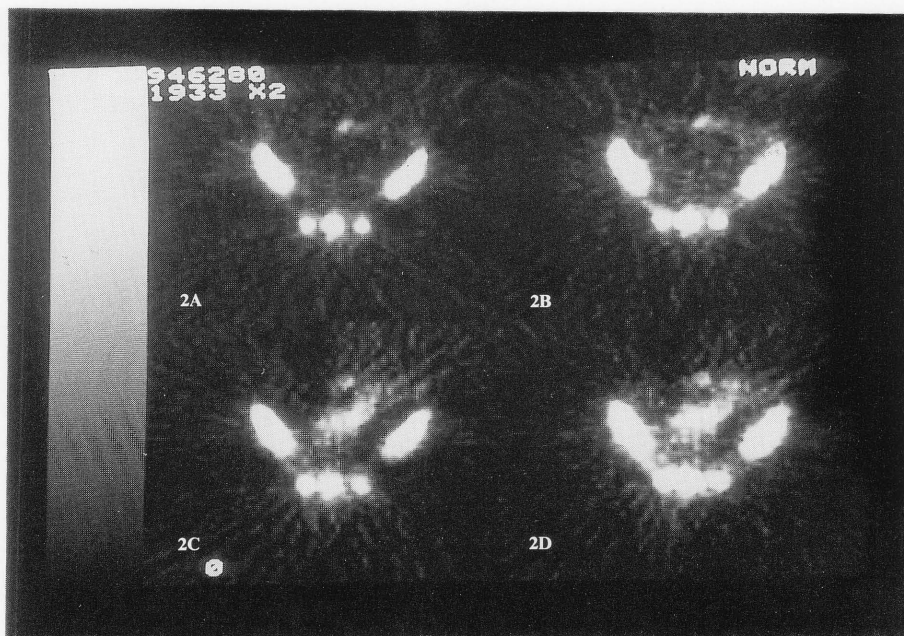
Fig. 2 For data acquired with a 64×64 matrix, a transaxial slice through the sacrum is shown.

    2A: Elliptical acquisition: Distance-weighted reconstruction.
    2B: Elliptical acquisition: Conventional reconstruction.
    2C: Circular acquisition: Distance-weighted reconstruction.
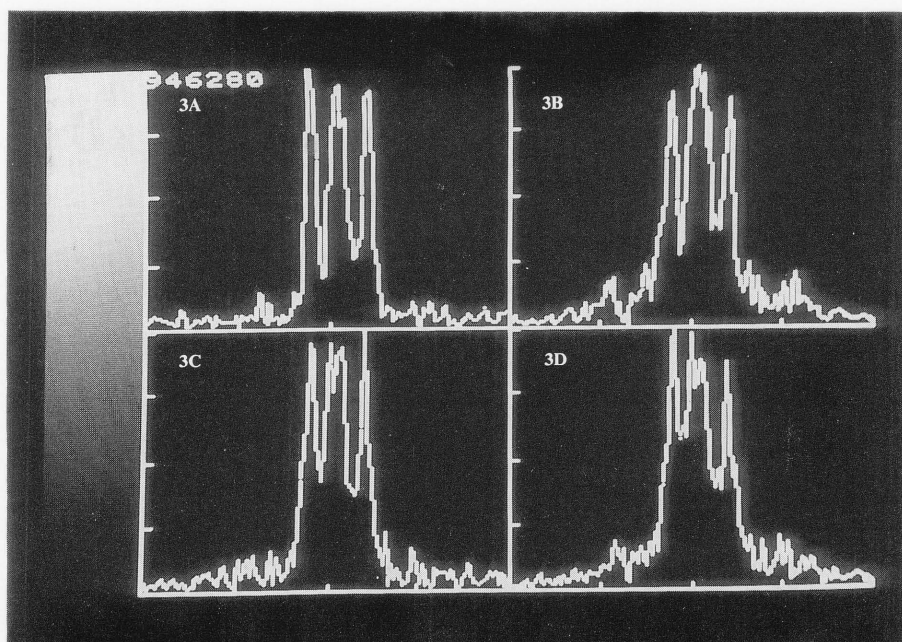   2D: Circular acquisition: Conventional reconstruction.

Fig. 3 For the transaxial slice images displayed in Fig. 1, profile curves are shown from a 14-pixel-thick band that encompassed the body of the sacrum and the sacroiliac joint regions.

    3A: Elliptical acquisition: Distance-weighted reconstruction.
    3B: Elliptical acquisition: Conventional reconstruction.
    3C: Circular acquisition: Distance-weighted reconstruction.
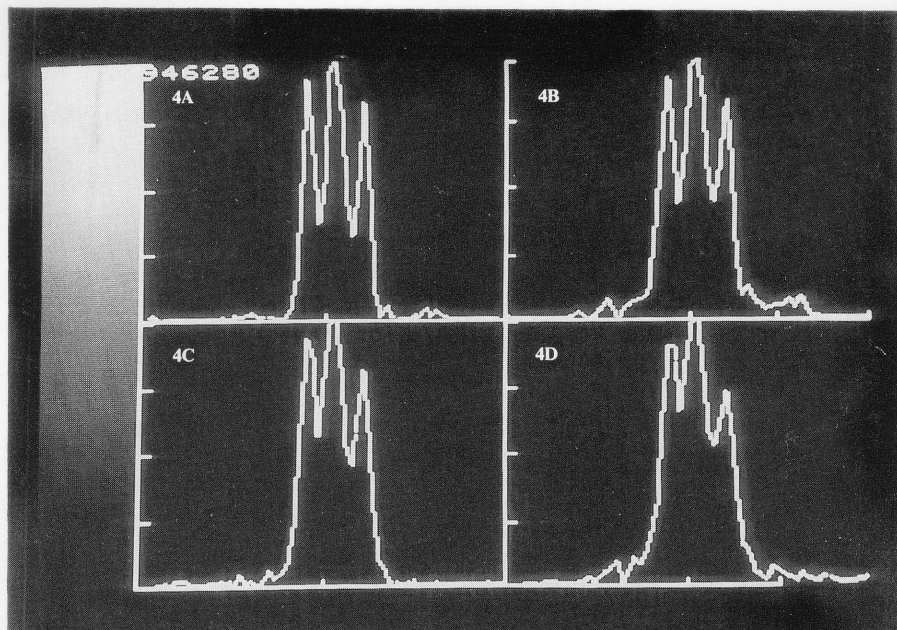   3D: Circular acquisition: Conventional reconstruction.

Fig. 4 For the transaxial slice image displayed in Fig. 2, profile curves are shown from a 7-pixel-thick band that encompassed the body of the sacrum and the sacroiliac joint regions.

4A: Elliptical acquisition: Distance-weighted reconstruction.
4B: Elliptical acquisition: Conventional reconstruction.
4C: Circular acquisition: Distance-weighted reconstruction.
4D: Circular acquisition: Conventional reconstruction.

shows the contrast for each acquisition and reconstruction combination. For corresponding acquisition matrix sizes, elliptical orbit images show better contrast than those from a circular orbit. Images obtained with a 128×128 acquisition matrix size show better contrast than do those corresponding to the 64×64 acquired images. Among all the processing alternatives, the elliptically acquired distance-weighted reconstruction with a 128×128 acquisition matrix size gives the best contrast.

DISCUSSION

Our initial experience with bone scanning of the pelvis has corroborated the results of phantom studies[1] in which improved spatial and contrast resolution was observed with an elliptical SPECT acquisition. A 128×128 (i.e. 3 mm $\times$ 3 mm) acquisition matrix provided the best tomographic image quality. The quality of elliptical orbit SPECT images was further enhanced with the distance-weighted filtered backprojection reconstruction algorithm.

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